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Final Report Part I

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DURABILITY & RELIABILITY OF SOLAR DOMESTIC HOT WATER HEATERS Survey Results

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PREFACE

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- Betty Hicks, University of Nevada, Reno
- David S.C. Chau, Arizona State University

SUMMARY

Opinions from 28 professionals, service contractors, and installers of solar domestic water heating (SDWH) systems about the reliability of SDWH system components were obtained via a comprehensive survey and follow-up interview. All individuals that participated in the survey have had significant field experience.

This report summarizes the survey results and provides a list of issues and their relative importance.

The system components were divided into two general categories:

1. Pumps, and plumbing fittings
2. Collectors, temperature sensors, tanks, pipe insulation and heat transfer fluid.

The major conclusions were:

- The mean lifetime for pumps and plumbing fittings was almost half of that for the collectors, temperature sensors, tanks, pipe insulation and heat transfer fluid.
- The most reliable components were drain ball valve, horizontal shaft pump, glass cover and collector enclosure.
- The least reliable components were mixing/tempering valve and untreated pipe insulation.
- High system cost and bad experience with solar systems were identified as the most significant problems facing the SDWH industry.
- Improper installation was identified as the largest factor contributing to the relatively high maintenance cost of the SDWH systems.

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1. INTRODUCTION

A) Purpose of survey

An unresolved barrier for consumer acceptance of SDWH systems is the perception that they are unreliable and that their service life is significantly less than that claimed by the manufactures/dealers.

A comprehensive survey was developed to identify and define the relevant durability and reliability issues that affect the long term performance of SDWH systems. The survey was directed towards installers and service contractors with significant field experience.

B) How the survey was accomplished

Initially the survey was sent to more than 300 companies with negligible response. The survey was then refined and modified. The second survey was directed towards selected companies in several geographic areas. A member of the research team made a personal visit to each respondent to pickup the completed survey and to clarify any questions regarding it.

C) Geographical areas serviced by survey participants

Phoenix, AZ

Los Angeles, CA

Sacramento, CA

Reno, NV

Eugene, OR

2. SURVEY PARTICIPANTS

A) Experience Level

- 0. Not answered
- 1. Closed loop
- 2. Closed loop (drain back)
- 3. Closed loop (antifreeze)
- 4. Open loop
- 5. Open loop (drain Back)
- 6. Open loop (recirculation)
- 7. Thermosyphon
- 8. ICS
- 9. Swimming Pool Systems
- 10. Distributor only

<u>Participant No.</u>	<u>Experience</u>
1	3,4,5
2	0
3	3,4,6,7,8
4	2,3
5	1,2,7
6	2,3,4,7,8
7	1,2,9
8	7
9	1,2,7,8
10	1,2,9
11	0
12	0
13	3,4,6,7,8
14	0
15	2
16	7
17	10
18	1,2,7,8
19	0
20	1,2,7
21	1,2,7,8
22	2,7
23	0
24	0
25	1,2,4,7
26	4,5,7
27	1,7
28	0

B) Number of Systems Installed and/or Maintained

How many systems have you installed and/or regularly maintained in the local area?

C) GEOGRAPHICAL DISTRIBUTION

Participant	Region
1,2	1-Reno
3,4,5,6,7,8	2-Phoenix
9,10,11,12,13,14	3-Sacramento
15,16,17,18,19,20,21,22,23,24	4-Los Angeles
25,26,27,28	5-Eugene

3. SURVEY RESULTS

- A) First group of components (Pumps, and plumbing fittings)
- B) Second group of components (Collectors, temperature sensors, tanks, pipe insulation and heat transfer fluid)
- C) General questions and responses

Note.- The vertical lines in the plots correspond to the value of the standard deviation.
Participants who have answered out of range (0 - 10) about the reliability index were not counted.

Durability and Reliability of Solar Domestic Hot Water Systems First Group of Components

First Failures Occur (FFO)

mean(FFO) = 5.1 years

The Items analysed are:

- 1.- Air Vents
- 2.- Draindown Valve
- 3.- Spring Check Valve
- 4.- Flapper Check Valve
- 5.- Drain Ball Valve
- 6.- Vent Valve
- 7.- Mixing/Tempering Valv
- 8.- P-T Relief Valve
- 9.- Pressure Relief Valve
- 10.- Horizontal Shaft Pump
- 11.- Vertical Shaft Pump

Durability and Reliability of Solar Domestic Hot Water Systems First Group of Components

Mean Lifetime (MLT)

mean(MLT) = 7.7 years

The Items analysed are:

- 1.- Air Vents
- 2.- Draindown Valve
- 3.- Spring Check Valve
- 4.- Flapper Check Valve
- 5.- Drain Ball Valve
- 6.- Vent Valve
- 7.- Mixing/Tempering Valv
- 8.- P-T Relief Valve
- 9.- Pressure Relief Valve
- 10.- Horizontal Shaft Pump
- 11.- Vertical Shaft Pump

Durability and Reliability of Solar Domestic Hot Water Systems First Group of Components

Reliability Index (RI), from 0 to 10

mean(RI) = 6.6

The Items analysed are:

- 1.- Air Vents
- 2.- Draindown Valve
- 3.- Spring Check Valve
- 4.- Flapper Check Valve
- 5.- Drain Ball Valve
- 6.- Vent Valve
- 7.- Mixing/Tempering Valve
- 8.- P-T Relief Valve
- 9.- Pressure Relief Valve
- 10.- Horizontal Shaft Pump
- 11.- Vertical Shaft Pump

Durability and Reliability of Solar Domestic Hot Water Systems

First Group of Components

FFO = First Failures Occur (years)

MLT = Mean Lifetime (years)

RI = Reliability Index (from 0 to 10)

mean(FFO) = 5.1

mean(MLT) = 7.7

mean(RI) = 6.6

The Items analysed are:

- 1.- Air Vents
- 2.- Draindown Valve
- 3.- Spring Check Valve
- 4.- Flapper Check Valve
- 5.- Drain Ball Valve
- 6.- Vent Valve
- 7.- Mixing/Tempering Valv
- 8.- P-T Relief Valve
- 9.- Pressure Relief Valve
- 10.- Horizontal Shaft Pump
- 11.- Vertical Shaft Pump

Durability and Reliability of Solar Domestic Hot Water Systems First Group of Components

Number of Participants

ND1 = Number of Participants in "First Failures Occur"

ND2 = Number of Participants in "Mean Lifetime"

ND3 = Number of Participants in "Reliability Index"

The Items "i" analysed are:

- 1.- Air Vents
- 2.- Draindown Valve
- 3.- Spring Check Valve
- 4.- Flapper Check Valve
- 5.- Drain Ball Valve
- 6.- Vent Valve
- 7.- Mixing/Tempering Valv
- 8.- P-T Relief Valve
- 9.- Pressure Relief Valve
- 10.- Horizontal Shaft Pump
- 11.- Vertical Shaft Pump

Durability and Reliability of Solar Domestic Hot Water Systems Second Group of Components

First Failures Occur (FFO)

mean(FFO) = 8.6 years

The Items analysed are:

1.- Collector (Passage blockage)	8.- Collector (Enclosure)	15.- Expansion Tank
2.- Collector (Cu abs. painted)	9.- Collector (Gaskets)	16.- Pipe Ins. (Painted)
3.- Collector (Cu abs. selective)	10.- Controllers	17.- Pipe Ins. (Al Tape)
4.- Collector (Al abs. painted)	11.- Temp. sensors	18.- Pipe Ins. (Untreated)
5.- Collector (Al abs. selective)	12.- Storage Tank (Glass lined)	19.- Glycol Fluid
6.- Collector (Fluid passages)	13.- Storage Tank (Steel)	
7.- Collector (Glass cover)	14.- Storage Tank (Thermostat)	

Durability and Reliability of Solar Domestic Hot Water Systems Second Group of Components

Mean Lifetime (MLT)

mean(MLT) = 15 years

The Items analysed are:

1.- Collector (Passage blockage) 2.- Collector (Cu abs. painted) 3.- Collector (Cu abs. selective) 4.- Collector (Al abs. painted) 5.- Collector (Al abs. selective) 6.- Collector (Fluid passages) 7.- Collector (Glass cover)	8.- Collector (Enclosure) 9.- Collector (Gaskets) 10.- Controllers 11.- Temp. sensors 12.- Storage Tank (Glass lined) 13.- Storage Tank (Steel) 14.- Storage Tank (Thermostat)	15.- Expansion Tank 16.- Pipe Ins. (Painted) 17.- Pipe Ins. (Al Tape) 18.- Pipe Ins. (Untreated) 19.- Glycol Fluid

Durability and Reliability of Solar Domestic Hot Water Systems Second Group of Components

Reliability Index (RI), from 0 to 10

mean(RI) = 7.9

The Items analysed are:

1.- Collector (Passage blockage)	8.- Collector (Enclosure)	15.- Expansion Tank
2.- Collector (Cu abs. painted)	9.- Collector (Gaskets)	16.- Pipe Ins. (Painted)
3.- Collector (Cu abs. selective)	10.- Controllers	17.- Pipe Ins. (Al Tape)
4.- Collector (Al abs. painted)	11.- Temp. sensors	18.- Pipe Ins. (Untreated)
5.- Collector (Al abs. selective)	12.- Storage Tank (Glass lined)	19.- Glycol Fluid
6.- Collector (Fluid passages)	13.- Storage Tank (Steel)	
7.- Collector (Glass cover)	14.- Storage Tank (Thermostat)	

Durability and Reliability of Solar Domestic Hot Water Systems Second Group of Components

FFO = First Failures Occur (years)

MLT = Mean Lifetime (years)

RI = Reliability Index (from 0 to 10)

mean(FFO) = 8.6 years

mean(MLT) = 15 years

mean(RI) = 7.9

The Items "i" analysed are:

1.- Collector (Passage blockage)	8.- Collector (Enclosure)	15.- Expansion Tank
2.- Collector (Cu abs. painted)	9.- Collector (Gaskets)	16.- Pipe Ins. (Painted)
3.- Collector (Cu abs. selective)	10.- Controllers	17.- Pipe Ins. (Al Tape)
4.- Collector (Al abs. painted)	11.- Temp. sensors	18.- Pipe Ins. (Untreated)
5.- Collector (Al abs. selective)	12.- Storage Tank (Glass lined)	19.- Glycol Fluid
6.- Collector (Fluid passages)	13.- Storage Tank (Steel)	
7.- Collector (Glass cover)	14.- Storage Tank (Thermostat)	

Durability and Reliability of Solar Domestic Hot Water Systems Second Group of Components

Number of Participants

FFO = First Failures Occur (years)

MLT = Mean Lifetime (years)

RI = Reliability Index (from 0 to 10)

NFFO = Number of Participants in FFO

NMLT = Number of Participants in MLT

NRI = Number of Participants in RI

The Items "i" analysed are:

1.- Collector (Passage blockage)	8.- Collector (Enclosure)	15.- Expansion Tank
2.- Collector (Cu abs. painted)	9.- Collector (Gaskets)	16.- Pipe Ins. (Painted)
3.- Collector (Cu abs. selective)	10.- Controllers	17.- Pipe Ins. (Al Tape)
4.- Collector (Al abs. painted)	11.- Temp. sensors	18.- Pipe Ins. (Untreated)
5.- Collector (Al abs. selective)	12.- Storage Tank (Glass lined)	19.- Glycol Fluid
6.- Collector (Fluid passages)	13.- Storage Tank (Steel)	
7.- Collector (Glass cover)	14.- Storage Tank (Thermostat)	

C) Open Ended Question Responses

The survey included several opinion questions that had no choices and no guidance for the answers. All similar answers were grouped together. The percent of respondents that gave similar answers is indicated.

What is the biggest problem facing the Solar Water Heating Industry today?

Number of Participants = 20

1. High investment and long pay back period	75 % *
2. Bad experience with solar systems	60 %
3. Low cost of natural gas	30 %

What factors seem to cause the most maintenance problems with the Solar Water Heating Systems ?

Number of Participants = 25

1. Improper installation	57 %
2. Bad water quality	52 %
3. Lack of regular maintenance	44 %

* Percent of the participants who have identified this situation as the answer.

What are the biggest maintenance problems you most often find with open loop systems?

Number of Participants = 25

1. Valves/Air vent	92% *
2. Control/Sensor	48 %
3. Pump	48 %
4. Freezing	36 %
5. Tank	20 %

What are the biggest maintenance problems you most often find with ICS systems?

Number of Participants = 21

1. Valves/Air vent	62%
2. Glazing	43 %
3. Tank	33 %
4. Collector	19 %
5. Freezing	14 %

* Percent of the participants who have identified this situation as the answer.

What are the biggest maintenance problems you most often find with Closed Loop systems?

Number of Participants = 22

1. Glycol	73 % *
2. Control/Sensor	41 %
3. Pump	32 %
4. Expansion tank	27 %
5. Valves/Air vent	23 %
6. Tank	18 %

What are the biggest maintenance problems you most often find with Thermosyphon systems?

Number of Participants = 23

1. Freezing	56 %
2. Valves/Air vent	52 %
3. Corrosion	30 %
4. Tank	30 %
5. Overheating	26 %
6. Heating element	22 %

* Percent of the participants who have identified this situation as the answer.

D) Other General Questions

How often does Vandalism occur ?

How often do you find damage to collector racks ?

How often does hail damage to collectors occur ?

How often do sensor lines require servicing ?

Do you believe that a shallow collector angle lengthens or shortens the lifetime of the Solar Water Heating System?

Do you believe that a latitude or larger collector angle lengthens or shortens the lifetime of the Solar Water Heating System?

Do you believe that a collector oversizing lengthens or shortens the lifetime of the Solar Water Heating System?

What is the Water quality in your service area?

Number of participants = 22

Have you measured total dissolved solids for your service area?

Number of participants = 8

What is the Water total alkalinity in your service area?

Number of participants = 7

What is the Water Calcium content in your service area?

Number of participants = 4

4. CONCLUSIONS

- The survey results show that the mean lifetime for the first group of components (pumps, and plumbing fittings) was almost half of the that for the second group (Collectors, temperature sensors, tanks, pipe insulation and heat transfer fluid).
- The reliability indexes for the two groups were comparable at 6-8 out of a scale 10.
- The most reliable components in the first group were drain ball valve and horizontal shaft pump. For the second group, glass cover and collector enclosure were the most reliable.
- The least reliable components were mixing/tempering valve and untreated pipe insulation for the first and second group respectively.
- High system cost and bad experience with solar systems were identified as the most significant problems facing the SDWH industry.
- Improper installation was identified as the largest factor contributing to the relatively high maintenance cost of the SDWH systems.

APPENDIX A

List of Participants

Buckingham, D., Solar Services, Anaheim
Campbell, D., Solar Self-Help, Inc., Concord
Carrozza, A., Scholfield Solar Energy Company, Inc., Ventura
Combs, J., Conservative Energy Systems, Mesa
Ellis, B., Environmental Solar Design, Inc., North Hollywood
Emrich, M., Solarponics, Inc., San Luis Obispo
Gunderson, B., Sun, Wind, & Fire, Portland
Hamasaki, L., Sun Utility Network, Los Angeles
Hilchrist, J., North Canyon Construction, Phoenix
Howland, J., Solarhart USA, San Marcos
Hoyt, C., Gardner Heating & Plumbing, Reno
Jerry, D & D Plumbing, Reno
Kennedy, G., Occidental Power, San Francisco
Landry, M., Horizon Industries, Escondido
Loer, M., Sierra Pacific Power, Sacramento
Loken, N., Solar Assist, Eugene
Mancebo, S., Home Energy Solutions, Sacramento
McRae, M., Mac's Solar, Santa Barbara
Mizany, R., Solar Depot, Sacramento
Neary, M., Desert Sun Solar, Inc., Phoenix
Parker, D., The Energy Service Co., Eugene
Pelton, B., Morley Manufacturing, Cedar Ridge
Reed, P., Pacific West Solar, Phoenix
Soden, P., The Stanley Louis Co., Redondo Beach
Spiek, D., EWEB, Eugene
Straton, J., Stanford Energy, Mountain View
Summers, R., Summers Solar Systems, Eugene
Walters, A., Payson Solar Electric, Payson
Walters, M., Sun Systems, Scottsdale
White, R., California Solar, Thousand Oaks

APPENDIX B

SURVEY

Arizona State University

Durability and Reliability of Solar Domestic Hot Water Systems

SOLAR WATER HEATING SYSTEM COMPONENT LIFETIME SURVEY

Introduction

Thank you for your participation in a solar water heating system survey conducted by Arizona State University and the National Renewable Energy Laboratory (funded by the Department of Energy, DoE). The goal of this study is to gather information on product durability and reliability, based on field experience, which will be used to develop systems and components with longer lifetimes. Opinions from professionals, such as yourself, will be studied and summarized to provide a list of issues and their relative importance. This list will then be submitted to a DoE-sponsored technical board for preparation of technical briefs and for prioritizing recommendations for DoE research.

The responses to each question will be compared and summarized in a way which is informative and useful. All answers to the questions contained in this survey will remain strictly confidential and you should feel free to give your honest opinion.

After we receive your survey responses, we will schedule a brief personal interview with you at a place and time of your convenience. The purpose of this interview will be to quickly confirm your responses so that we do not make any mistakes in interpretation. This interview will also be an excellent opportunity for us to gain further insight from you on any responses which we do not fully understand. This interview will also give you the opportunity to suggest problems you have observed with solar water heating systems, solutions you have found to problems, or additions you think we should make to the survey.

Again, thank you for sharing your time and experience.

Byard Wood, PhD, P.E.
Professor of Mechanical Engineering

Kent Whitfield, Project Engineer

Betty Hicks, Research Specialist

SECTION I.

For questions A through I, please fill in your responses, in order of importance, on the lines provided. Place the most important (or most frequent) response on line 1 and the least important (least frequent) on line 5. Feel free to use the back of this survey if you have more than five responses to each question. If a response seems to fit equally well for two (or more) questions, feel free to write the question letter and number on the response line where you think it best belongs (such as "see A.2" to refer to your response on question A, number 2). If you have no opinion, or the question does not apply to you, please write "NA".

A. What types of solar water heating systems do you install (for example, open/closed loop, flat plate, thermosyphon, ICS etc.)?

1.	
2.	
3.	
4.	
5.	

B. What types of solar water heating systems do you regularly service?

1.	
2.	
3.	
4.	
5.	

C. Roughly, how many systems have you installed and/or regularly maintained in the local area?

circle one choice

1-25	25-100	100-200	200-300	300-500	500 or more
------	--------	---------	---------	---------	-------------

D. What do you perceive to be the biggest problem facing the solar water heating industry today?

1.	
2.	
3.	
4.	
5.	

E. What factors (*in order of importance*) seem to cause the most maintenance problems with solar water heating systems in general?

1.

2.

3.

4.

5.

F. What general installation practice(s) (*in order of importance*) seem to cause most maintenance problems with solar water heating systems?

1.

2.

3.

4.

5.

For questions G through K. indicate maintenance problems with the specified systems if you install or maintain these systems.

G. What are the biggest maintenance problems you most often find with open loop (recirculation or draindown) systems?

1.

2.

3.

4.

5.

H. What are the biggest maintenance problems you most often find with ICS systems?

1.

2.

3.

4.

5.

I. What are the biggest maintenance problems you most often find with closed loop (glycol and/or drainback) systems?

1.

2.

3.

4.

5.

J. What are the biggest maintenance problems you most often find with thermosyphon systems?

1. _____
2. _____
3. _____
4. _____
5. _____

Question K applies if you install or service system types not specifically called-out in questions G through J.

System Type-_____.

K. What are the biggest maintenance problems you most often find with this system type?

1. _____
2. _____
3. _____
4. _____
5. _____

(please use the back of this sheet for more system types)

SECTION II.

In this next set of questions, please consider the average lifetimes of different solar water heating system components. The lifetime estimates should be indicative of solar water heating systems manufactured and installed within the last ten years. Feel free to estimate ranges or round numbers.

Example:

FIRST FAILURES OCCUR

2-3

or

FIRST FAILURES OCCUR

4

To indicate that first failures for this particular component occur from between two and three years, or for a different component, failures usually occur after about four years. If the amount of time to failure is less than one year, use a fraction (such as, 1/2 for six months) or use a whole number and the word "mo." or "months". If you are not sure about an estimate, leave that line blank or write "no opinion".

The third column asks you, on a scale of 1 to 10, to assign a reliability index to the part in question. A reliability of 10 should indicate that the part never fails in the field while a reliability of 1 should indicate that the part often fails after only a few months of service.

This information will be used to help determine the reliability and lifetime of different solar water heating components. This reliability can then be used to focus efforts of researchers and industry to develop solutions to premature component failures. Your input is crucial to this effort!

The lifetime estimates below should be for your service area or territory.

- A. In general, how would you rate the water quality in your service area? _____
- B. Have you measured or researched the total dissolved solids (ppm, μ mho, etc.) for your area and if so could you share with us what it is? _____
- C. Do you know the total alkalinity (ppm or mg/L) or hardness (grains) area and if so could you share with us what it is? _____
- D. Do you know the calcium content (ppm or mg/L) area and if so could you share with us what it is? _____
- E. Does water quality affect the way in which you service a solar water heating system, and if so, how?

Please use the "ADDITIONAL PART" rows at the bottom of section F to: a) specify components that are not listed explicitly, or b) to point out a particular type/manufacturer of a general part that has, in your experience, a significantly different reliability than the average part. For example, if a component in general has a 20 year mean lifetime, but a particular manufacturer's same component fails after about two years, please list the manufacturer and/or specific component in the additional part box.

F.	FIRST FAILURES OCCUR	MEAN LIFETIME	RELIABILITY INDEX (1 - 10)	NO OPINION
AIR VENTS				
DRAINDOWN VALVE				
CHECK VALVES SPRING CHECKS				
CHECK VALVES FLAPPER CHECKS				
DRAIN BALL VALVES				
VENT VALVES				
MIXING (OR TEMPERING) VALVES				
PRESSURE AND TEMPERATURE (P-T) RELIEF VALVES				
PRESSURE (P) RELIEF VALVES				
PUMPS SHAFT HORIZONTAL				
PUMPS SHAFT VERTICAL				
COLLECTOR PASSAGE LEAKAGE				

F. cont.

	FIRST FAILURES OCCUR	MEAN LIFETIME	RELIABILITY INDEX (1 - 10)	NO OPINION
COLLECTOR PASSAGE BLOCKAGE				
COLLECTOR COPPER ABSORBER PLATES, PAINTED SURFACE OUTGASSING OR GENERAL DETERIORATION				
COLLECTOR COPPER ABSORBER PLATES, SELECTIVE SURFACE OUTGASSING OR GENERAL DETERIORATION				
COLLECTOR ALUMINUM ABSORBER PLATES, PAINTED SURFACE OUTGASSING OR GENERAL DETERIORATION				
COLLECTOR ALUMINUM ABSORBER PLATES, SELECTIVE SURFACE OUTGASSING OR GENERAL DETERIORATION				
COLLECTOR FLUID PASSAGES ON ABSORBER BONDING OR CORROSION FAILURE				
COLLECTOR GLASS COVER				
COLLECTOR ENCLOSURE				
COLLECTOR GASKETS				
CONTROLLERS				
TEMPERATURE SENSORS				
STORAGE TANKS GLASS LINED				
STORAGE TANKS STEEL				
STORAGE TANKS THERMOSTAT FAILURES				
EXPANSION TANKS				
EXTERIOR PIPE INSULATION PAINTED COVERING				
EXTERIOR PIPE INSULATION ALUMINUM TAPE COVERING				
EXTERIOR PIPE INSULATION UNTREATED COVERING				
GLYCOL FLUID				
ADDITIONAL PART:				
ADDITIONAL PART:				
ADDITIONAL PART:				
ADDITIONAL PART:				
ADDITIONAL PART:				
ADDITIONAL PART:				
ADDITIONAL PART:				

G. Does your experience indicate that a shallow collector mounting angle (up to around 25°) influences the lifetime of solar water heating systems and components? Please circle one response.

strongly agree	agree	no opinion	disagree	strongly disagree
----------------	-------	------------	----------	-------------------

If you expressed an opinion in question G, do you believe that a shallow collector mounting angle *lengthens* or *shortens* the lifetimes of solar water heating systems and components? Please circle one response, or go on to the next question.

shortens	lengthens
----------	-----------

H. Does your experience indicate that a latitude (or larger) collector mounting angle influences the lifetime of solar water heating systems and components? Please circle one response.

strongly agree	agree	no opinion	disagree	strongly disagree
----------------	-------	------------	----------	-------------------

If you expressed an opinion in question H, do you believe that a latitude (or larger) collector mounting angle *lengthens* or *shortens* the lifetimes of solar water heating systems and components? Please circle one response, or go on to the next question.

shortens	lengthens
----------	-----------

I. Does your experience indicate that system oversizing (collector oversizing) influences the lifetime of solar water heating systems and components? Please circle one response.

strongly agree	agree	no opinion	disagree	strongly disagree
----------------	-------	------------	----------	-------------------

If you expressed an opinion in question I, do you believe that system oversizing (collector oversizing) *lengthens* or *shortens* the lifetimes of solar water heating systems and components? Please circle one response, or go on to the next question.

shortens	lengthens
----------	-----------

J. In your experience, how often does vandalism of solar water heating collectors occur? Please circle one response.

very often	often	sometimes	rarely	very rarely
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K. In your experience, how often do you have to service, or find damage to collector racks? Please circle one response.

very often	often	sometimes	rarely	very rarely
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L. In your experience, how often does hail damage of solar water heating collectors occur? Please circle one response.

very often	often	sometimes	rarely	very rarely
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M. In your experience, how often do sensor lines require servicing? Please circle one response.

very often	often	sometimes	rarely	very rarely
------------	-------	-----------	--------	-------------

N. Are there any other factors which influence solar water heating system component lifetimes that we have not included but probably should? Please use the back of this sheet if you have more than three suggestions.

1. _____
2. _____
3. _____

SECTION III.

How would you most like to be kept informed of current improvements in the installation and maintenance of solar water heating systems? Please consider the different ways that this information could be provided to you and mark an "x" in the appropriate column. For example, if you find a particular method to be helpful or somewhat helpful, place an "x" in the "helpful" column. At the end of this section, please feel free to suggest other methods of obtaining reliability information to improve the installation, maintenance and service of solar water heating systems. (You can also use the comments section to suggest how to change the format of the survey questions.)

Please indicate your interest in the following ways of gaining information.

	VERY HELPFUL	HELPFUL	NO OPINION	NOT HELPFUL	COUNTER- PRODUCTIVE
guest speaker (SEIA)					
single sheet bulletins (mailed)					
single sheet bulletins (at chapter SEIA meetings)					
column in chapter newsletter					
multi-page technical briefs (requested by post card or by phone)					
Internet Web page					
computer bulletin board					
personnel training courses					
video taped training					

Comments:

This image shows a single sheet of white paper with horizontal ruling lines. The lines are evenly spaced and run across the width of the page. There are no margins, text, or other markings on the paper.